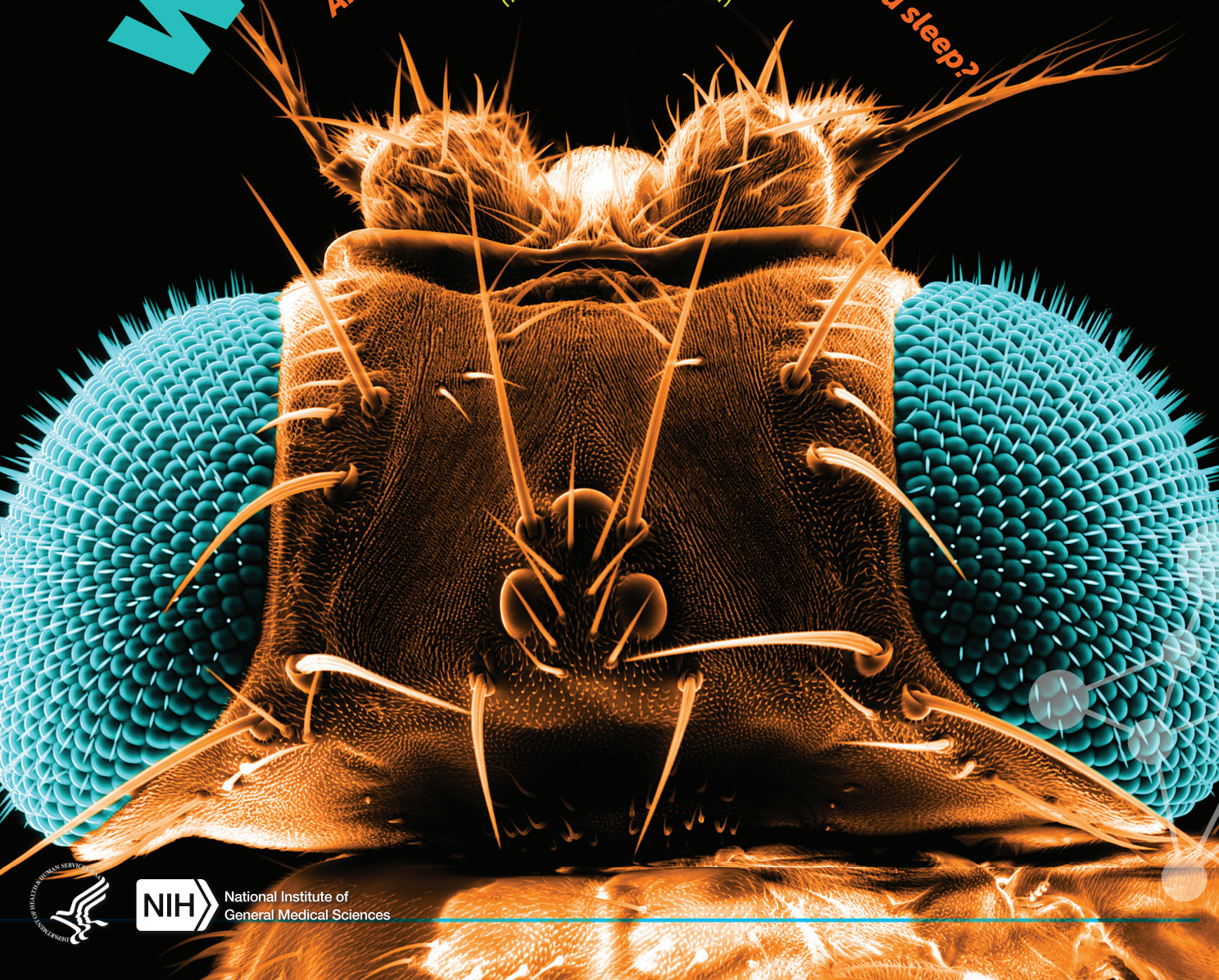


# PATHWAYS

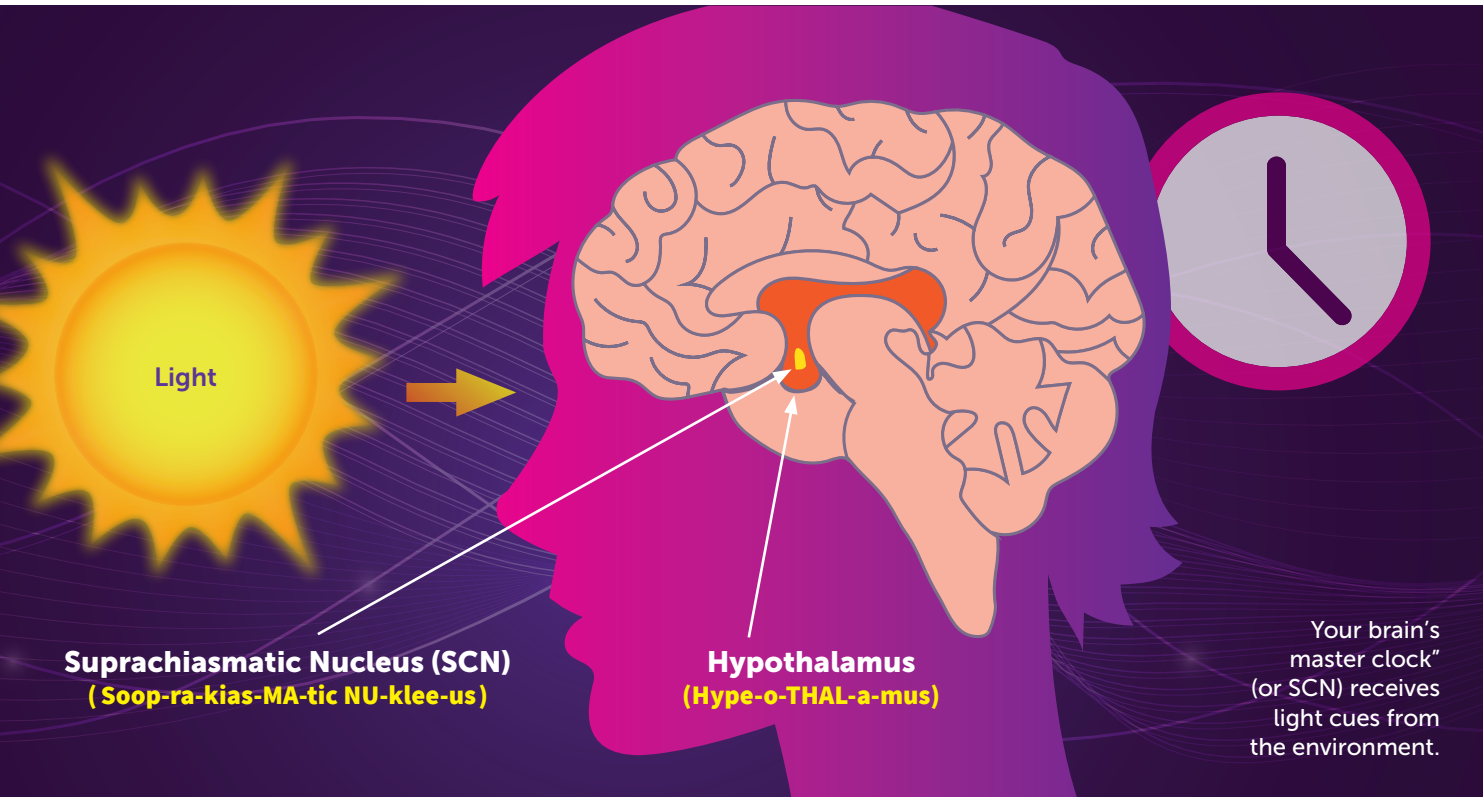
**What is this?**  
*And what does it have to do with how you sleep?*  
(Find out inside!)



National Institute of  
General Medical Sciences

# The Science of

What researchers are learning about the body's daily rhythms, and how they determine when you fall asleep, wake up, and more!



**W**hat makes you drift off to sleep at around the same time every night? Why do you usually feel a snack attack coming on in the late afternoon? The answer: your circadian rhythms. You can't see them or feel them, but all humans have circadian rhythms—and so do most living things, including animals, plants, and even fruit flies! Circadian rhythms are powerful: They control physical, mental, and behavioral changes that you experience over the course of a 24-hour day.

What's driving those circadian rhythms? Bodily clocks! Humans have a "master clock" in the brain. This master clock, called the suprachiasmatic nucleus (SCN), contains about 20,000 nerve cells called neurons. It's located in a small, powerful

region of the brain called the hypothalamus. The SCN receives direct messages about when it's light and dark from the sensory receptors in your eyes. It then communicates this info to the rest of the brain and cells in the body. "These SCN neurons in our brain are like clocks that keep track of the time of day, and help synchronize our bodies with the daily rhythms that occur as the Earth rotates on its axis every 24 hours," explains **Dan Cavanaugh, Ph.D.**, assistant professor at Loyola University Chicago. "It's why we get sleepy or wake up at particular times."

The time that your body likes to go to sleep, which is called your chronotype (think of it as your sleep personality), can change. "Research

# Sleep

shows that as you enter your teenage years, it's normal to become more of a night owl, which means you want to stay up later," says **Carrie Partch, Ph.D.**, associate professor at the University of California, Santa Cruz. This shift is caused by the normal hormonal changes that happen during puberty. For example, in teens, the levels of melatonin, a sleep-inducing hormone, also rise later in the day than they do in kids and adults. Girls typically start puberty earlier, and some studies suggest they begin shifting toward a late-night chronotype about a year sooner than boys do. "In your early twenties, though, your hormones start to settle, and that urge to stay up later goes away," says Partch.

And circadian rhythms affect more than just your sleep-wake cycle. They can impact other important functions in your body. "Scientists know that we have a master clock in our brains, but we're only beginning to appreciate how widespread these clocks are," says **Swathi Yadlapalli, Ph.D.**, assistant professor at the University of Michigan. "Recent studies show that almost every cell in the human body has a circadian clock, so there

are clocks in most of our organs: the liver, intestines, lungs, skin, and more." Irregular rhythms can cause health conditions like sleep disorders, obesity, and diabetes.

## Light Effects

Your internal clock is amazingly reliable. But there is one major factor that could make it go off-kilter: changing your exposure to light. You've probably heard the term "jet lag." If someone travels a long distance to another time zone, they may feel groggy all day. That's because their internal clock isn't lined up with the light and dark cues in their new environment. People who work at night—like nurses and nighttime security guards—also have a hard time getting their circadian clocks to match up with their outside world. Their internal clock, which takes its cues from daytime light, makes it hard for them to stay asleep, even if they're tired.

## The Phone Factor

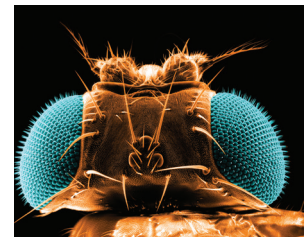
Scientists have found that using blue-light-emitting devices like smartphones at night can mess up your internal clock in the same way.

"Even though it's not from the sun, the light from a phone tells your internal clock that it's daytime, even at 10 or 11 p.m.," says Partch. The clock confusion can also drag down your energy levels, make you feel crabby, and impair your judgment.

Teens need eight to 10 hours of sleep a night. You might think you're doing a smart thing by "catching up" with a 12-hour sleep binge on the weekend, but you're only throwing off your circadian rhythms. The best strategy is to go to bed and get up at the same time every day, even on weekends, and turn off your devices 30 minutes before bedtime.

## The Mystery Cover Image

Say hello to *Drosophila*, otherwise known as a fruit fly. See the "Science All-Stars" section to learn how these research organisms have helped us decode circadian rhythms. The image shows its head and large, light-sensitive eyes.



**Circadian rhythm** comes from the Latin words *circa*, which means "around," and *diem* or *dies*, meaning "day." The study of circadian rhythms is called chronobiology.

## SCIENCE ALL-STARS



Ever wonder what it would be like to win a Nobel Prize? In 2017, scientists **Jeffrey C. Hall, Michael Rosbash, and Michael W. Young** won the prestigious honor for their circadian rhythms research. By studying *Drosophila*,

aka fruit flies, which have a very similar genetic makeup to humans, they isolated a gene that helps control the body's clock. The scientists showed that the gene produces a protein, **PER**, that builds up in cells overnight, then breaks down during the day. This process can affect when you sleep, how sharply your brain functions, and more.

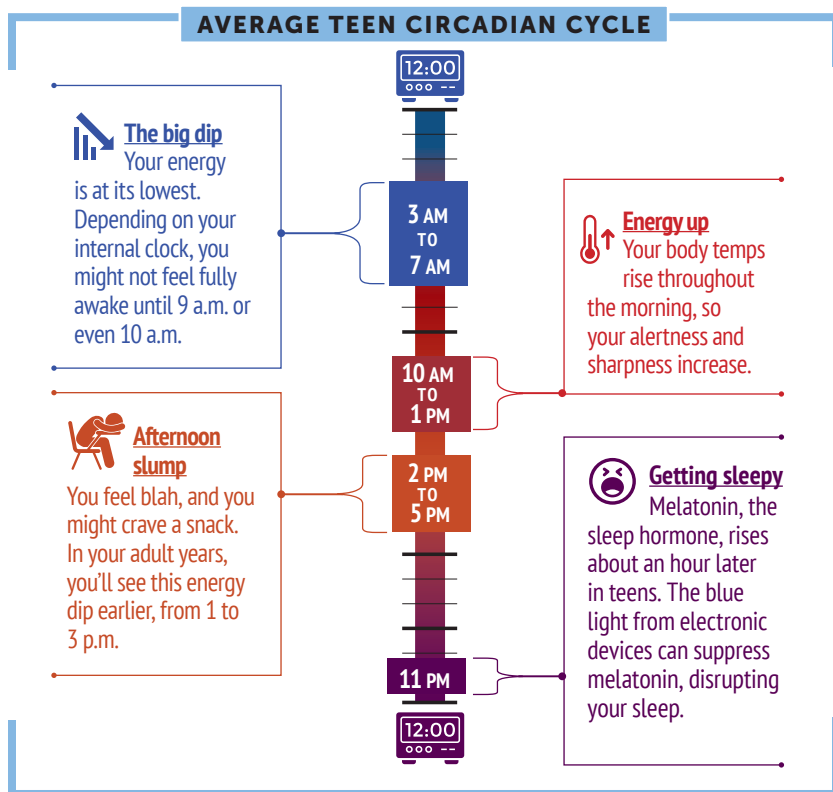
# Should Teens Be Allowed to Sleep In?

Some school districts are saying yes to improve students' health.

Your phone alarm goes off and you've got to drag yourself out of bed to get ready for school. Ugh. If you feel like climbing back under the covers, it's probably not your fault: Many teenagers' circadian clocks aren't ready to solve algebra problems before 8 a.m.—and science backs this up.

When Seattle, Washington, switched its school start time from 7:50 a.m. to 8:45 a.m., students got more sleep and better grades, according to researchers at the University of Washington and Salk Institute for Biological Studies. In fact, California recently became the first state to ban high school start times before 8:30 a.m. Middle school can't begin until 8 a.m.

Check out the graphic at right to see what a body clock looks like on school days for the typical teenager.



## In the Spotlight Early-Career Scientists



**Dustin Ernst, Ph.D.**, postdoctoral fellow at the University of California, San Diego

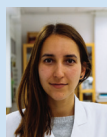
**What sparked your interest in science?**

In middle school, I had a very enthusiastic teacher who showed me how much fun science can be. I really enjoyed setting up experiments and working with my hands.

**What research are you doing now?** I'm investigating how circadian rhythms controlled by biological clocks help microbes survive and reproduce. The biological clock found in the microbe I work with is different than the human biological clock. But the underlying principles are similar, so our research may help us discover how biological clocks influence human health.

**Any advice for students who want to become scientists?**

Look for classes that require problem-solving. Get as much lab experience as you can. Join a science club at your school, and get involved in activities that require creative, out-of-the-box thinking.



**Filipa Rijo-Ferreira, Ph.D.**, postdoctoral associate, University of Texas Southwestern Medical Center

**Did you like science as a kid?** Yes! I've always been fascinated by biology and wildlife TV shows.

In high school, I had the most amazing biology teachers. They were all women, and it was like, wow, they're all doing this—I could, too.

**What do you hope to discover?** I'm trying to find out if parasites, which cause devastating diseases, have a way to tell time—if a parasite has a clock. One of the major symptoms of the malaria disease is its periodic fevers that happen at very specific times of day, always in multiples of 24 hours—like a circadian clock. If parasites have a clock and you can disrupt that, you can control the infection.

**How can students find out more about science careers?**

Get exposed to as many things as you can so you can see what most fascinates you. Be curious about the world around you. Be persistent.